

**SYSTEM AND METHOD FOR POLLING DEVICES IN A NETWORK SYSTEM****CROSS-REFERENCE TO RELATED APPLICATION**

This application claims priority to and the benefit of the filing date of co-pending  
5 and commonly assigned Provisional Application having Serial No. 60/160,127, entitled  
"Method For Polling ATM Remote Physical Devices in an ATM System," filed October  
18, 1999, having attorney docket number 61606-8230 (1999-16) and hereby incorporated  
by reference.

**TECHNICAL FIELD**

The present invention relates generally to the field of communications and  
computing systems and methods for transmitting and exchanging data between two  
points, and more specifically, to the field of broadband packet routing and switching and  
asynchronous transfer mode (ATM) in data communications for transporting information  
15 between module layers.

**BACKGROUND OF THE INVENTION**

Communications networks involve moving information from one entity to  
another. Communications networks, from the very basic to the highly advanced, require  
20 varied information to be grouped at a source entity, transmitted, and then ungrouped at a  
destination entity. An inherent problem in communications networks involves the  
process of multiplexing and demultiplexing information to be transmitted. This problem  
is greatly intensified in high speed networks where rapid processing and transmission

requirements magnify the issues surrounding multiplexing and demultiplexing data. In an attempt to address this problem, a plurality of high-speed communications network protocols have adopted complex control signals to control the flow of information. One such network protocol is asynchronous transfer mode (ATM).

5 Historically, ATM networks have been some of the few communications networks that support simultaneous transmission of voice, video, and data. The ATM network protocol is a connection-oriented protocol that utilizes short fixed-length packets called "cells". The use of cells allows ATM networks to provide high-throughput, low delay, and service-independent transport. The user of an ATM network is not assigned a static  
10 bandwidth as in time division multiplexed systems; the user can obtain dynamically allocated bandwidth and bandwidth on demand. ATM devices typically support network links that carry traffic of a plurality of different protocols at a plurality of different speeds. One ATM node might simultaneously support the data traffic of a plurality of xDSL modems, DS1, DS3, OC-3, OC-12, E1, E3, STM-1, and/or STM-4 connections. The  
15 protocol of ATM was designed to facilitate the implementation of varied services in hardware, thus resulting in the ability to quickly process data with little incurred delay. In order to rapidly process the data relating to the multiple subscriber links, the ATM node must have an efficient means by which to interface with these subscriber links. This interface can be described as the interface between the ATM Layer and the Physical  
20 Layer.

The ATM protocol has a hierarchical layered structure which is similar to the open systems interconnection (OSI) reference model. The physical layer of the ATM

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levels, the ATM switching system must be able implement scheduling and buffering techniques to minimize loss and prioritize traffic in the most efficient manner possible. This implementation involves a plurality of considerations, and these considerations are of concern to most standard ATM switching systems.

5           The standard ATM switching fabric involves an ATM Layer Device which typically processes data at a rate far faster than any of its associated physical (PHY) layer devices. For example, a typical ATM layer traffic processing device operating at rates of 622Mbps may be employed for ATM traffic processing for DS3 (45mbps), DS1 (1.544Mbps), or DSL (144Kbps to 8Mbps) ports in a switching system. In this case the

10   high speed ATM layer device can be shared across a multitude of low speed physical layer interfaces. The requirement for sharing the ATM layer across multiple physical layer interfaces is a very typical architecture for an ATM node. ATM switching systems providing large numbers of low/medium speed traffic interfaces can achieve greater port densities at lower cost by sharing the ATM layer over a greater number of port interfaces.

15   For example, in a DSLAM or broadband access concentrator application, the ATM node has a small number of high bandwidth uplinks and a large group of lower bandwidth subscriber links. In this manner, the ATM node multiplexes a plurality of subscriber links onto a high bandwidth link to a larger network. Thereby, the ATM layer device must have the ability to interface with multiple PHY layer devices. The universal test and

20   operations physical interface for ATM (UTOPIA) protocol defines a standard interface between the ATM layer and PHY layer of an ATM switching system. The UTOPIA interface specification defines the control signals to be interchanged between the ATM

layer and PHY layer, the timing relationships of control signals and data flow, and the management and control of such an interface. As mentioned earlier, the ATM layer devices multiplex data onto high bandwidth links. In accordance with this characteristic, UTOPIA level 1 was designed to support an 8-bit cell transfer mode to support a single interface at rates up to 155 Mbps (OC-3). The UTOPIA level 2 specification was designed to include a 16-bit cell transfer supporting multiple physical interfaces having a combined line rate up to 622 Mbps (OC-12). In order to interface high speed ATM layer traffic processors and not incur buffer over-run at the PHY layer devices, the UTOPIA specification designates certain flow control signals to be communicated between the two layers. This allows the ATM layer to be rate matched to the PHY layer in order to service the PHY layer at its corresponding transmission rate.

FIG. 1 depicts the flow control signals in accordance with the prior art, UTOPIA Level 1 and 2. The UTOPIA standard specifies an addressing process enabled by a 5 bit addressing signal. A PHY Layer Device 180A is identified in a reception by a 5 bit TxAddr[B:0] 115 signal. A PHY Layer Device 180A is identified in a transmission by a 5 bit RxAddr[B:0] 145 signal. The flow control signals and the data transmissions described by UTOPIA are synchronized by a transmit clock, TxClk 135, and a receive clock, RxClk 165. In the 8-bit mode, the clocking rate is usually 25 Mhz and double that rate, 50 Mhz, for 16-bit mode. An additional synchronization signal indicates the beginning of cell transfer. Start-Of-Cell, TxSOC 125 or RxSOC 155, designates when the data signal, Transmit Data (TxData[A:0]) 110 or Receive Data (RxData[A:0]) 140, contains the first valid byte of a cell. UTOPIA requires a PHY Layer Device to

implement rate matching buffers, *i.e.* FIFO's. Although the PHY Layer Device FIFOs are necessary, they are usually of minimal size (2-4 cells). With such small buffers, the two layers must be able to indicate their respective statuses in order to process communication data successfully. The ATM Layer 101 indicates status by asserting the Transmit Enable, TxEnb 130, signal when TxData 110 contains valid cell data. In addition, the ATM Layer 101 asserts the Received Enable, RxEnb 160, to indicate that RxData 140 and RxSOC 155 will be sampled at the end of the next cycle. The PHY Layer Device communicates status by asserting Cell Available signals. Transmit Cell Available, TxClav 120, is asserted to indicate the PHY Layer Device can accept the transfer of a cell. Receive Cell Available, RxClav 150, is asserted to indicate the PHY Layer has a cell ready for transfer to the ATM Layer.

It is apparent that the aforementioned flow control signals are extensive and can be quite cumbersome on the system as a whole. This complicated flow control is a result of the inherent nature of the ATM protocol. The ATM protocol is a connection oriented, protocol independent, cell based solution. Thus, ATM requires that each cell be independently processed. As technology expands, the cumbersome flow control signals become a more significant problem. As previously mentioned, ATM nodes in broadband network access applications most typically multiplex data from a plurality of low bandwidth subscriber links onto one high bandwidth network link. A typical ATM node is, for example but not limited to, a digital subscriber line access module (DSLAM). A DSLAM might aggregate multiple ADSL G.992.2 (G.Lite) subscribers onto a single OC-12 interface to an upstream network. In this case, the DSLAM would have the bandwidth

capacity to multiplex up to 414 G.Lite 1.5 Mbps subscribers on to one 622 Mbps OC-12 interface. Thus, the ATM layer devices of the DSLAM would have to communicate to a large number of the ADSL PHY layer devices. This example illustrates the limitations of the cumbersome flow control requirements of UTOPIA. UTOPIA specifies a 5-bit  
5 address field for the PHY Layer Devices. A 5-bit address field results in 32 possible addresses in which one address is reserved for idle transactions. Therefore, an ATM layer device operating in accordance with the UTOPIA specification can only support 31 PHY layer device interfaces. As exemplified by the above DSLAM discussion, this characteristic would be severely limiting for a high bandwidth ATM node attempting to  
10 support 411 PHY layer devices. This would require the ATM node to have at least 14 ATM layer devices.

The limitations of the flow control specification within UTOPIA have many significant impacts. The boundary of 31 PHY Layer Devices to a single ATM Layer Device greatly affects the cost of an ATM switching system. The ATM Layer Devices  
15 are fairly costly due to their bandwidth performance, traffic processing and traffic management complexity, and ability to support large amounts of high-speed cell buffers. In view of the ever-increasing processing rates of electronics hardware, it would be extremely costly to have the amount of ATM Layer Devices dictated not by the processing capacity but by the specifications of an interface standard.

20 Another problem resulting from the UTOPIA limitation is the increase in complexity of the ATM switching system. In the system described above with 14 ATM layer devices, a complex hierarchy of control signals would most likely be required in

order manage the processes on the 14 devices. This management would be greatly simplified by reducing the amount of ATM layer devices that are necessary.

### **SUMMARY OF THE INVENTION**

5           The current invention provides a system for transmitting and receiving information comprising a first layer transceiver device, a plurality of second layer transceiver devices, and an interface connecting the first layer transceiver device and the a plurality of second layer transceiver devices. The first layer transceiver device and the a plurality of second layer transceiver devices transmit and receive information and control  
10   signals over the interface to control the transmission and reception of the information. One of these signals is a time division multiplexed (TDM) signal that indicates the availability of one of the second layer transceiver devices. The use of a TDM signal to indicate the availability of a second layer transceiver device greatly reduces the number of distinct control signals required in a system to support a large number of PHY devices  
15   across an ATM layer device. It also allows status from the PHY devices to be reported to the ATM layer with a guaranteed latency in a reliable manner. The TDM nature of the signal also allows a plurality of PHY devices partitioned onto multiple components in the system to share the same physical control signals to for reporting PHY status.

          Another aspect of the current invention provides a system for transmitting and  
20   receiving information comprising a first layer transceiver device, a plurality of second layer transceiver devices, and an interface connecting the first layer transceiver device and a plurality of second layer transceiver devices. The first layer transceiver device and a



plurality of second layer transceiver devices transmit and receive said information across said interface in addition to control signals to control the transmission and reception of information over said interface. This information is encapsulated in a protocol data unit (PDU) comprising an address for one of the a plurality of second layer transceiver

5 devices.

Other systems, methods, features, and advantages of the present invention will be or become apparent to one with skill in the art upon examination of the following drawings and detailed description. It is intended that such additional systems, methods, features, and advantages be included within this description, be within the scope of the

10 present invention, and be protected by the accompanying claims. While this invention specifically cites a physical embodiment for controlling traffic between an ATM layer and PHY layer in an ATM switching system it is certainly not limited to that. The mechanisms described herein can certainly be applied to any communications device where multiple LAN or WAN interfaces can be managed by a single high speed instance

15 of the traffic processing device. In this case the protocols described in this invention for allowing multiple physical layer interface devices to indicate their readiness to the traffic processing device for transmission/reception of data and multiplexing of traffic between the PHY layers and traffic layer can be readily applied to ethernet or IP packets, frame relay frames. This technique can be readily used for processing traffic in ethernet

20 switches, gigabit/terabit IP routers and switches, and frame relay switches.

**BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS**

The accompanying drawings, incorporated in and forming a part of the specification, illustrate several aspects of the present invention, and together with the description serve to explain the principles of the invention. The components in the drawings are not necessarily to scale, emphasis instead being placed upon clearly illustrating the principles of the present invention. Moreover, in the drawings, like reference numerals designate corresponding parts throughout the several views. In the drawings:

FIG. 1 is a diagram showing the UTOPIA interface signals between the PHY  
10 Layer and the ATM Layer in accordance with prior art;

FIG. 2 is a diagram of some of the possible devices and connections that can exist in a network surrounding an ATM switching system containing the current invention, a polling system;

FIG. 3 is a high level diagram of the processing layers and associated interfaces  
15 that exist in an ATM switching system displayed in FIG. 2;

FIG. 4A is a diagram illustrating the polling system in FIG. 2 and the interface signals between communicating layers of one embodiment of the present invention;

FIG. 4B is a diagram illustrating the polling system in FIG. 2 and the interface signals between communicating layers of an alternate embodiment of the present  
20 invention;

FIG. 4C is a diagram depicting an alternate embodiment of the polling system in FIG. 2 in which the PHY Layer CLAV\_Status Device interfaces to a plurality of sets of traditional UTOPIA PHY Layer Devices;

FIG. 4D is a diagram depicting an alternate embodiment of the polling system in  
5 FIG. 2 in which the PHY Layer CLAV\_Status Device is partitioned into a plurality of Sub PHY Layer CLAV\_Status Devices which interface with sets of traditional UTOPIA PHY Layer Devices;

FIG. 5 is a graph depicting the timing relationships of the control signals that are communicated between the ATM Layer CLAV\_Status Device and the PHY Layer  
10 CLAV\_Status Device as shown in FIG. 4A, 4B, and 4C;

FIG. 6 is a graph of the timing relationships in which one PHY device operates at a higher speed relative to the other PHY devices in the system according to an embodiment of the present invention as shown in FIG. 4A, 4B, and 4C;

FIG. 7 is a diagram illustrating the addressing system using a 16 Bit data bus and  
15 a 16 Bit addressing scheme for the polling system in FIG. 2 according to an embodiment of the present invention;

FIG. 8 illustrates the addressing scheme of an embodiment of the current invention for the polling system in FIG. 2 in which the width of the data bus and the number of addressing bits is defined by the user.

## **DETAILED DESCRIPTION OF THE INVENTION**

Having summarized various aspects of the present invention, reference will now be made in detail to the description of the invention as illustrated in the drawings. While the invention will be described in connection with these drawings, there is no intent to  
5 limit it to the embodiment or embodiments disclosed therein. On the contrary, the intent is to cover alternatives, modifications and equivalents included within the spirit and scope of the invention as defined by the appended claims.

As networking communications rapidly expand, the amount of protocols, interfaces, and system architectures to support these communications expand at the same  
10 rapid pace. This phenomenon focuses a spotlight on those network systems that are able to support fast, reliable, and protocol independent transportation. ATM is a network protocol that embodies these traits. In order to support the vast amount of varied protocols, an ATM switching system must be able to interface to many different types of devices. As illustrated in FIG. 2, a typical ATM switching system 201 has a plurality of  
15 different physical interfaces supporting various network protocols. FIG. 2 shows an ATM switching system supporting a DSL Modem 211 connected by a twisted pair copper loop 210. Another type of DSL connection is shown by the VoDSL Modem 221 supporting telephones 222 and 223 over the twisted pair copper connection 220. In addition to DSL service, a typical ATM switching system supports a router 231 via an  
20 ATM WAN 230 interface. The ATM switching system 201 in FIG. 2 also serves as a transportation unit for other networks. The ATM switching system 201 supports an additional ATM Network 242 over a DS3 240 interface to an ATM node 241. The

optical OC-3 link 250 connects another ATM network, an ATM network interconnected by a fiber ring 251. The ATM switching system 201 supports its subscriber links through WAN connections to other networks. Such WAN connections are typified by a DS3 link 260 to a frame relay network 261, an OC-12 interface to an ATM network 271, and a  
5 DS1 280 interface to the internet 281. It is apparent that in order for the ATM switching system 201 to support a large amount of multi-protocol subscriber interfaces, the system must be able to efficiently manage and control these interfaces.

Before continuing the detailed description, it will be useful to set forth some terms and their definitions in this context. A module can be defined as the areas within a  
10 protocol. A module being any entity that performs a set of designated functions. The module can be a co-dependent unit within a system or an independent unit with inputs and outputs. A device can be unit within a layer that performs a set of functionality associated with that layer. A transceiver is a unit that is enabled to input and output information. A transceiver, as the word suggests, can both transmit information and  
15 receive information. Many different methods can be used by transceivers to communicate data. The transceiver can communicate over, for example but not limited to, a radio, electrical, or optical link. An ethernet is a local area network (LAN) protocol based on a packet frame, usually operating at 10 Mbps. A local area network (LAN) is network of multiple interconnected data terminals or devices within a local area to facilitate data  
20 transfer. In contrast a wide area network (WAN) is typically a network of geographically distributed networks that provide high volume trunk links. Internet protocol (IP) is a specification for a particular data unit that is common to many packet delivery services.

A protocol data unit (PDU) embodies any grouping of data to be transmitted and received in a specified manner.

The hierarchy of the ATM protocol is depicted in Fig. 3. The ATM model can be broken down into the five areas shown in FIG. 3. The lowest layer of the protocol is labeled as the Physical (PHY) Layer 350. The PHY Layer 350 is the layer that interprets the electrical impulses communicated across the input and output to an ATM system. The PHY Layer communicates its electrical interpretations over the PHY-to-ATM Layer interface 345. This interface 345 transmits data to be processed by the ATM Layer 340 and receives data from the ATM Layer 340 to be outputted by the PHY Layer 350. The ATM Layer 340 interprets and generates the headers of cell traffic. ATM Layer 340 communicates this cell traffic with the ATM Adaptation Layer ("AAL") 330. The AAL Layer 330 is the layer that performs segmentation and reassembly (SAR) and the convergence sublayer (CS) functions. SAR involves segmenting protocol data units (PDUs) from the Higher Layers 320 into ATM appropriate cells and reassembling data from ATM cells into the PDUs of the Higher Layers 320. The SAR and CS processes enable enhanced adaptation of ATM services. The AAL Layer 330 communicates PDUs with the Higher Layers 320 over the AAL-to-Higher Layer Interface 325. The Higher Layers interface with first level applications through the communication of PDUs transmitted and received over the AAL-to-Higher Layer Interface 325. The layers of ATM functionality are centrally controlled by Management and Control 310. An ATM network node typically processes at PHY layer 350 and the ATM layer 340 for the data plane. The other layers are typically performed by the end nodes in the network. The

ATM node typically only processes the higher in support of the management and control planes activities.

In the manner described above and illustrated by FIG. 3, the ATM switching system 201 (FIG. 2) can manage, process, interpret, and transport information from an electrical signal to a high level PDU and vice versa. It is apparent that the processing required to perform the varied functions of an ATM switching system is demanding. Therefore, it would be advantageous, for a plurality of reasons, to be able to centrally locate a large portion of this processing. FIG. 4A, 4B, and 4C represent an embodiment of the polling system 200 (FIG. 2) in which the ATM Layer can more efficiently interface with more PHY Layers than possible in the current art.

In FIG. 4A, the ATM Layer CLAV\_Status Device 400 communicates the standard UTOPIA control signals and data between ATM Layer CLAV\_Status Device 400 and the ATM Layer 101 (FIG. 1). The ATM Layer CLAV\_Status Device 400 processes the control signals and data for greater efficiency and speed. In one embodiment the ATM Layer CLAV\_Status Device 400 may assimilate the communicated data to adhere to a desired data transport format. One embodiment of such a data transport function may be to implement two separate one directional buses of bit width N, where N is a desired number of bits. Another embodiment may implement ATM\_Data 410 as a serial data bus as described in U.S. Patent Application having Serial No. 09/267,048, filed on March 12, 1999, and entitled "System and Method for Transmission between ATM Layer Devices and PHY Layer Devices Over a Serial Bus" which is incorporated herein by reference. In the above embodiments and other potential embodiments, ATM\_Data 410 communicates

data between the ATM Layer CLAV\_Status Device 400 and the PHY Layer  
CLAV\_Status Device 450. In addition to data communication, the ATM Layer  
CLAV\_Status Device 400 may assimilate the control signals communicated with the  
ATM Layer 101 (FIG. 1). The ATM Layer CLAV\_Status Device 400 generates a  
5 CLAV\_SYNC 420 and a CLAV\_CLK 440 signal to be transmitted to the PHY Layer  
CLAV\_Status Device 450. These signals will be described in detail later in the  
discussion of FIG. 5. The ATM Layer CLAV\_Status Device 400 also receives a  
CLAV\_Status 430 signal from the PHY Layer CLAV\_Status Device 450 to be  
communicated to the ATM Layer 101 (FIG. 1). This CLAV\_Status 430 signal contains  
10 the cell availability information from the PHY devices within the system. The ATM  
Layer CLAV\_Status Device 400 interprets the information communicated in the  
CLAV\_Status signal and generates the appropriate RxClav 150 (FIG. 1) and TxClav 120  
(FIG. 1) signals. These RxClav 150 (FIG. 1) and TxClav 120 (FIG. 1) signals are then  
transmitted to the ATM Layer 101 (FIG. 1).

15 A system and method for implementing a novel and advantageous PHY Layer  
addressing scheme is also depicted in Fig 4A. The ATM Layer CLAV\_Status Device 400  
not only assimilates control signals communicated regarding cell communication, but the  
ATM Layer CLAV\_Status Device 400 also generates and interprets addressing  
information. In one embodiment the ATM Layer CLAV\_Status Device 400 receives the  
20 address on the TxAddr[B:0] 115 (FIG. 1) signal of one of a PHY Layers 180 (FIG. 1) for  
which the upcoming data on TxData[A:0] 110 (FIG. 1) is destined. The ATM Layer  
CLAV\_Status Device 400 then incorporates this addressing information into the



ATM\_Data 410 communication. In a similar manner, the ATM Layer CLAV\_Status Device 400 pulls addressing information out of a received portion of data in ATM\_Data and waits for a corresponding RxAddr[B:0] 145 poll from ATM Layer 101 (FIG. 1) signal to indicate the source PHY Layers 180 data currently being received on

5 RxData[A:0] 145 (FIG. 1). One implementation of the above addressing scheme is embodied in a PHY-Tag 840 (FIG. 8). The use of the PHY-Tag 840 (FIG. 8) involves placing the address for a particular PHY Layer into the user defined area of an ATM cell. The details of this implementation are found in the detailed description of FIG. 7 and FIG. 8.

10 As previously mentioned one of the elements with which the ATM Layer CLAV\_Status Device 400 communicates data and control signals is the PHY Layer CLAV\_Status Device 450. The PHY Layer CLAV\_Status Device 450 performs functions similar to that of the ATM Layer CLAV\_Status Device 400. The data communicated by ATM\_Data 410 is processed by the PHY Layer CLAV\_Status Device 15 450 according to the data transport format embodiment discussed above. The PHY Layer CLAV\_Status Device 450 pulls the data portion of a received ATM\_Data 410 transmission and generates an appropriate TxData[A:0] 110 (FIG. 1) transmission. The PHY Layer CLAV\_Status Device 450 also pulls the PHY-Tag 840 (FIG. 8) from the ATM\_Data 410 transmission and applies it to the TxAddr[B:0] 115. The PHY Layer 20 CLAV\_Status Device 450 also polls PHY Layer devices 180A- 180B using TxAddr[B:0] 115 for TxClav status 120. It relays the TxClav status 120 to the ATM Layer CLAV\_Status device using the CLAV\_Status 430.

The PHY Layer CLAV\_Status Device 450 also receives a RxData[A:0] 140 (FIG. 1) transmission from one of the PHY Layers 180 (FIG. 1) and processes the data to be communicated by ATM\_Data 410. In conjunction with processing data, the PHY Layer CLAV\_Status Device 450 implements the addressing scheme previously described.

5 Thus, in one embodiment the PHY Layer CLAV\_Status Device 450 can receive from the PHY Layer 180 (FIG. 1) associated by polling the RxAddr[B:0] 145 (FIG. 1) signal during a data transfer cycle and incorporate that address into the ATM\_Data 410 transfer. This address information is embedded in the PHY-Tag 840 (FIG. 8) of the receive ATM\_Data 410 transfer.

10 FIG. 4A illustrates how the PHY Layer CLAV\_Status Device 450 receives both a CLAV\_SYNC 420 and a CLAV\_CLK 440 signal from the ATM Layer CLAV\_Status Device 400. The PHY Layer CLAV\_Status Device 450 interprets the information communicated in these signals to generate the appropriate control signals to be communicated to the PHY Layers 180. In addition the PHY Layer CLAV\_Status Device  
15 450 generates a CLAV\_Status 430 signal to be transmitted to the ATM Layer CLAV\_Status Device 400. The CLAV\_Status 430 signal contains the information regarding the cell availability of the PHY Layers 180 (FIG. 1) in the system. This CLAV\_Status signal is described in detail below in the discussion of FIG. 5 and FIG. 6.

FIG. 4B represents one embodiment of the present invention in which the ATM  
20 Layer CLAV\_Status Device 400 is included as subcomponent of the ATM Layer 401. Those of ordinary skill in the art will recognize that it is possible to change the divisions or combinations of hardware and software functional blocks within a system. In FIG. 4B,

the ATM Layer CLAV\_Status Device 400 is implemented as a subcomponent of functionality within the ATM Layer 401. It is recognized that the ATM Layer CLAV\_Status Device 400 could be implemented in a distinct area of logic within an ATM Layer 401 processing unit. As described earlier, the ATM Layer 401 is a complex processing unit and thus it would be likely for a design to combine the ATM Layer CLAV\_Status Device 400 functionality into the logic of the ATM Layer 401. This would allow the ATM Layer 401 to bypass the limitations of UTOPIA control signals and process direct from information communicated by the PHY Layer CLAV\_Status Device 450. This embodiment would modify the ATM Layer 401 to incorporate the ATM Layer CLAV\_Status Device 450 directly.

It is appreciated by those of ordinary skill in the art that there are many different ways to group the work of different hardware and software modules to achieve an equivalent resulting functionality. One embodiment would enable the present invention to operate with existing standard ATM Layer devices and PHY Layer devices. Another embodiment would allow the ATM Layer CLAV\_Status Device 400 to interface with an enhanced ATM Layer 401. The enhancement would comprise added functionality enabled to interpret and create control signals regarding the CLAV\_Status input 460. In the case of the CLAV\_Status 460, information could be communicated to the ATM Layer 401 to indicate the cell availability status of PHY Layers outside of the existing standard limitations. Thus, the CLAV\_Status 460 would potentially carry information about PHY Layer Devices 32 and above, those not included in the standard TxClav 120 (FIG. 1) and RxClav 150 (FIG. 1) signals. For example, but not limited to, the CLAV\_Status 460

signal would communicate information which is not supported by the standard control signals interfaces to the ATM Layer 101 (FIG. 1). One embodiment of the CLAV\_Status 460 signal would communicate information for which it is not possible or not desired to communicate over the standard UTOPIA bus.

5 Another embodiment of the polling system 200 (FIG. 2) could involve communicating a special CLAV\_Status cell. In this case, the ATM Layer CLAV\_STATUS device would consolidate the TDM CLAV\_Status from the PHY Layer CLAV\_STATUS devices. It would then create a special CLAV\_Status cell that is transmitted to the ATM Layer device. In this case the CLAV\_Status cell could be included in the data stream and the information within this special data cell would be used to define cell availability characteristics of the PHY Layer 180 (FIG. 1). This allows the existing ATM layer interface to handle the expanded PHY devices without requiring a special CLAV\_STATUS interface.

FIG. 4C is a diagram that demonstrates a significant embodiment of the polling system 200 (FIG. 2). In FIG. 4C the PHY Layer CLAV\_Status Device 450 controls the control signals and data flow to a 1st Set of Standard UTOPIA PHY Layer Devices 480A, a 2nd Set of Standard UTOPIA PHY Layer Devices 480B, and a Nth Set of Standard UTOPIA PHY Layer Devices 480C. One embodiment of the present invention enables the PHY Layer CLAV\_Status Device 450 to create the standard UTOPIA control signals. This implementation would involve the PHY Layer CLAV\_Status Device 450 transmitting and receiving the control signals illustrated in the prior art, UTOPIA. One advantage of this implementation is that the PHY Layer CLAV\_Status Device 450 could

control the control signals and data flow of many times more PHY Layer Devices than possible under the current UTOPIA specifications. Thus, instead of interfacing with one set of 31 PHY Layer Devices, the system could interface with many times more than 31 PHY Layer Devices that are arranged in groups of the standard 31. Another advantage of such an embodiment of the polling system 200 (FIG. 2) is that the PHY Layer Devices would not have to be adapted in any way. Employing the above embodiment of the present invention would allow a system to easily interact with any PHY devices complying with the UTOPIA standards. The system of the present invention could enable the advantages discussed above without modification to PHY Layer Devices.

FIG. 4D shows an alternative embodiment of FIG. 4C in which the PHY Layer CLAV\_Status Devices 450 can be partitioned into multiple instances allowing greater scalability. As shown in FIG. 4D, the ATM Layer CLAV Status Device 400 can interface to multiple PHY Layer CLAV Status Devices 450A – 450N. In this case each PHY Layer CLAV Status device 450A – 450N relays CLAV status from its respective set of UTOPIA PHY layer devices 480A- 480C to the ATM Layer CLAV Status Device 400. The PHY Layer CLAV Status 450A – 450N may support 1 or more standard UTOPIA buses. In this example, the 1<sup>st</sup> PHY Layer CLAV Status device 450A supports the 1<sup>st</sup> set of Standard UTOPIA PHY Level Devices 480A, and the Nth PHY Layer CLAV Status device 450N supports the 2<sup>nd</sup> Set of Standard UTOPIA PHY Level Devices 480B through the Nth 480C Set of Standard UTOPIA PHY Level Devices. CLAV Status from each of the PHY Layer CLAV Status devices is aggregated to the ATM Layer CLAV Status device by utilizing the TDM control protocol of the CLAV Status Bus (signals 420, 430,

and 440). Each PHY Layer CLAV Status device is assigned time slots on the TDM CLAV Status Bus for the respective PHY Layer devices 480. Synchronization between PHY Layer CLAV Status Devices 450A – 450N is maintained by CLAV\_CLK 420 and CLAV\_SYNC 440. During a time slot in which status for a particular PHY Layer Device 480 is driven onto the bus, the associated PHY Layer CLAV Status 450A – 450N drives the CLAV\_Status signal 430. The remaining PHY Layer CLAV Status Devices 450A – 450N that are not responsible for the associated PHY Layer device 480 remain in a tri-state mode.

It is respectfully asserted that one ordinary skilled in the art would recognize that the plurality of PHY Layer CLAV\_Status Devices (450A – 450N) could be modules within a single PHY Layer CLAV\_Status Device 450 or separate entities. This partitioning allows for easy, rapid, and manageable scaling of a hierarchy for greater efficiency.

FIG. 5 is a diagram illustrating the timing relationships of the signaling communicated between the ATM Layer CLAV\_Status Device 400 (FIG. 4A) and the PHY Layer CLAV\_Status Device 450 (FIG. 4A). The timing diagram shown in FIG. 5 is of an arbitrary time scale and the curved lines toward the end of the diagram indicate a break in the time sequence. The CLAV\_CLK 440A signal is the reference clock for which the cell availability signaling is referenced. The CLAV\_SYNC 420A signal is a signal generated to demarcate the beginning of a cell availability report period. The CLAV\_Status 430A signal is a time division multiplexed signal that contains the cell availability of the PHY Layers 180 (FIG. 1). One time slot is used to indicate TXCLAV

status 120, another time slot may be used to indicate RXCLAV status 150. The PHY Layer CLAV\_Status Device 450 (FIG. 4A) monitors the CLAV\_SYNC signal 420A to determine when it should begin a period of reporting the cell availability status of the PHY Layers 180 (FIG. 1). When the CLAV\_SYNC 420A signal is asserted, as shown at clock edge 0, then the PHY Layer CLAV\_Status Device 450 (FIG. 4A) begins to write cell availability information to the CLAV\_Status 430A signal. In one embodiment, depicted in FIG. 5, the PHY Layer CLAV\_Status Device 450 (FIG. 4A) writes the TXClav cell availability of PHY Layer 1 180A (FIG. 1) at clock edge 1 to CLAV\_Status 430A. Next, the PHY Layer CLAV\_Status Device 450 (FIG. 4A) writes the RXClav cell availability of PHY Layer 1 at clock edge 2 to CLAV\_Status 430A. At clock edge 3 Layer CLAV\_Status Device 450 (FIG. 4A) writes the TXClav cell availability of PHY Layer 2 180A (FIG. 1) to CLAV\_Status 430A. Next, the PHY Layer CLAV\_Status Device 450 (FIG. 4A) writes the RXclav cell availability of PHY Layer 2 at clock edge 4 to CLAV\_Status 430A. In this manner the PHY Layer CLAV\_Status Device 450 (FIG. 4A) writes the cell availability information of the PHY Layers 180 (FIG. 1) to the CLAV\_Status signal in succession. One embodiment of the invention implements the CLAV\_Status write procedure by using the PHY Layer's 180 (FIG. 1) addresses. In accordance with prior art, namely the UTOPIA Level 2 specification, a PHY Layer is assigned an address by a management entity. The PHY Layer CLAV\_Status Device 450 (FIG. 4A) uses these addresses to create a time delay factor. Thus PHY Layer 1 180A (FIG. 1) has its TXClav and RXClav cell availability status written to the CLAV\_Status after zero and one clock cycle delays. PHY Layer 2 has its cell availability status written

to the CLAV\_Status 430A signal after a delay of two and three clock cycles. PHY Layer N 180B (FIG. 1) has its cell availability status written to the CLAV\_Status 430A signal after a delay of  $(2*N-2)$  and  $(2*N-1)$  clock cycles. The following formulas define the delay calculation used in this embodiment:

5           Clock Cycle to Write to TXCLAV CLAV\_Status =  $2*PHY\ Layer\ address - 2$

          Clock Cycle to Write to RXCLAV CLAV\_Status =  $2*PHY\ Layer\ address - 1$

The PHY Layer CLAV\_Status Device 450 (FIG. 4A) may thereby use the addresses assigned to the PHY Layers 180 (FIG. 1) to create a time division multiplexed

CLAV\_Status signal 430A. It also asserted that one skilled in the art may ascertain  
10   another algorithm for assigning time slots for reporting CLAV Status to respective PHY layer devices.

FIG. 6 illustrates another embodiment of the timing relationships of the signaling communicated between the ATM Layer CLAV\_Status Device 400 (FIG. 4A) and the PHY Layer CLAV\_Status Device 450 (FIG. 4A). The timing diagram shown in FIG. 6  
15   demonstrates a modification to the signaling techniques described in FIG. 5. As previously mentioned, it is typical for an ATM system to service many different types of subscriber links that operate at many different speeds. This variance in subscriber speeds necessitates that different PHY Layers operate at different speeds. Thereby, the ATM system must be able to handle data and signaling operating at varying rates of speed.

20   FIG. 6 illustrates one embodiment of the Polling System 200 (FIG. 2) in which a higher speed PHY Layer has its cell availability status written to the CLAV\_Status 430B more often than the other lower speed PHY Layers. The timing diagram shown in FIG. 6 is of



an arbitrary time scale and the curved lines toward the end of the diagram indicate a break in the time sequence. As shown in FIG. 6, the CLAV\_SYNC 420B is asserted at clock edge 0. Responsive to this sync signal, the PHY Layer CLAV\_Status Device 450 (FIG. 4A) writes the TXCLAV cell availability of PHY Layer 1 180A (FIG. 1) to the CLAV\_Status 430B signal at clock edge 1. At clock edge 2, the PHY Layer CLAV\_Status Device 450 (FIG. 4A) writes the RXCLAV cell availability of PHY Layer 1. At clock edge 3, the PHY Layer CLAV\_Status Device 450 (FIG. 4A) writes the TXCLAV cell availability of PHY Layer 2. At clock edge 4, the PHY Layer CLAV\_Status Device 450 (FIG. 4A) writes the RXCLAV cell availability of PHY Layer 2. Next, the PHY Layer CLAV\_Status Device 450 (FIG. 4A) again writes the TXCLAV cell availability of PHY Layer 1 180A (FIG. 1) to CLAV\_Status 430B that exists at clock edge 5. In the example set forth by FIG. 6, PHY Layer 1 180A (FIG. 1) is a much higher speed device than the other PHY Layers 180 (FIG. 1) and thus requires to have its cell availability status transmitted more than the others. The modification exemplified in FIG. 6 creates a time division multiplexed CLAV\_Status 430B signal in which priorities are exercised by the PHY Layer CLAV\_Status Device 450 (FIG. 4A) and higher speed PHY Layers are allocated more time slots.

FIG. 5 and FIG. 6 illustrate how a TDM sync signal (CLAV\_SYNC 420) can be used to define a sync period. This sync period is the time period necessary for the PHY devices in a system to transfer their TxClav/RxClav signal status. One embodiment of the present invention implements the length of the sync period to be equal to the number of PHY devices in the system. For example, if there are 8 PHY devices in the system

then the sync period would be 8 clock cycles long. A further extension on one embodiment of the polling system 200 (FIG. 2) would be to allow the length of the sync period to dynamically change responsive to the addition and deletion of PHY devices to the system. In accordance with the discussion of FIG. 6, another embodiment of the polling system 200 (FIG. 2) could result in allowing particular PHY devices to report more than once in a sync period. For one embodiment example, consider a system in which there is a combination of DS1 PHY devices (1.544 Mbps) and DS3 PHY devices (44.1236 Mbps) and a cell is a standard 53 byte ATM cell. A DS1 interface has a transfer rate of 3.6K cells/second, or 1 cell every 277  $\mu$ s. A DS3 transfers a cell every 9  $\mu$ s (microseconds). Suppose in this example a 25 Mhz clock is used to support cell availability polling of 512 PHY devices. Thus, there is a clock edge every 40 ns (nanosecond). With 512 PHY devices, one frame of the sync period is 20  $\mu$ s long. In this implementation, the 20  $\mu$ s frame time is enough to meet the response time requirements of a DS1 PHY device with the potential to transmit 1 cell every 277  $\mu$ s. However, the 20  $\mu$ s frame time is too slow to support the response time requirements of a DS3 device with the potential to transmit or receive a cell every 9  $\mu$ s. To meet the response time requirements the system will have to take advantage of the system and method of one of the embodiments of the polling system 200 (FIG. 2) previously described in the discussion of FIG. 6. The implementation can meet the response time requirements of the DS3 by allowing the DS3 PHY devices to report to CLAV\_Status a plurality of times during the sync period. If the DS3 channel applied CLAV\_Status 28 times per frame, response time would be approximately 731 ns.

FIG. 7 illustrates one embodiment of the present invention with respect to a novel and advantageous addressing scheme. The diagram in FIG. 7 depicts the format of a data Protocol Data Unit (PDU) to be communicated on ATM\_Data 410 (FIG. 4A). In this embodiment, the data PDU is 16 Bits wide, 16 BIT WIDE PDU 700, and carries information that can be broken down into three main sections. These sections are Header Data 710, User Defined (UDF) 720, and Payload Data 730. In this embodiment the Header Data 710 section and the Payload Data 730 are not modified from the standard in the art. The present invention implements an addressing scheme by making use of the UDF 720 section. One embodiment of the polling system 200 (FIG. 2) creates a 16\_BIT\_PHY\_TAG 740 to be placed in the UDF 720 section. This UDF 720 section is 16 bits wide and thus the 16\_BIT\_PHY\_TAG 740. This implementation creates an address for a PHY Layer that can be wide as the 16\_BIT\_PHY\_TAG 740, which in this case means up to  $2^{16}$ , 65536, distinct addresses can be created. The system uses this tag to implement addressing in the following manner. When the ATM Layer CLAV\_Status Device 400 (FIG. 4A) communicates a 16 Bit Wide PDU 700, it creates or interprets a 16\_BIT\_PHY\_TAG 740 to indicate the source PHY device or the destination PHY device. Also, when the PHY Layer CLAV\_Status Device 450 (FIG. 4A) communicates a 16 Bit Wide PDU 700, it creates or interprets a 16\_BIT\_PHY\_TAG 740 to indicate the source PHY device or the destination PHY device. This embodiment enables an inband addressing method that requires no extra addressing measures and every data PDU is directly associated with address of PHY device from which it came or for which it is destined.

FIG. 8 exhibits an embodiment of the present invention in which the PDU 800 width and PHY\_TAG 840 are of undefined lengths. This figure illustrates how the method of data transfer and addressing described in earlier discussions can be

implemented to adhere to requirements of a particular design. The PDU 800 is of width

5 N, where N can be a value that best matches the requirements of the design. For example but not limited to, if the design required a large data transport size then N could equal 64 and the data bus would be 64 bits wide. This embodiment also calls for the PHY\_TAG 840 to be of length X, where X is defined by the requirements of the design at hand. The number of possible PHY devices to be addressed can be changed by changing the value of  
10 X, thereby make the PHY\_TAG 840 larger or smaller.

It is respectfully asserted that the embodiments of the polling system above are applicable to a variety of protocols. The discussion above focused on the polling system as implemented in an ATM environment and more specifically UTOPIA. One skilled in the art will recognize the application of the polling system in protocols such as ethernet,  
15 IP, MPLS, frame relay, or any protocol in which a controlling traffic processing device communicates data with a plurality of other physical interface devices in the system. As previously mentioned the polling system addresses the problem of having cumbersome flow control signals when pluralities of devices are trying to communicate. This cumbersome flow control signal problem exists in a plurality of circumstances with a  
20 plurality of protocols and the polling system method can be applied to these circumstances and protocols.

In all embodiments of the present invention, as described in detail in this disclosure, there is transmission and reception. It is respectfully asserted that anyone of ordinary skill in the art will recognize that one of these sides of data flow or control signals could be deleted from the system. For example, in many ATM switching systems the ATM layer processing bandwidth is greater than the total of the maximum potential bandwidths for the subscriber links. In this circumstance, it would not be necessary to have control signals for data coming from the PHY Layer because the ATM Layer would be able to handle the data. Similarly many other embodiments can be construed of the present invention in which only transmission or only reception considerations are of concern. In any manner, all embodiments still use the teachings set forth by the polling system 200 (FIG. 2).

The polling system 200 (FIG. 2) of the present invention can be implemented in hardware, software, firmware, or a combination thereof. In the preferred embodiment(s), the polling system 200 (FIG. 2) is implemented in software or firmware that is stored in a memory and that is executed by a suitable instruction execution system. If implemented in hardware, as in an alternative embodiment, the polling system 200 (FIG. 2) can be implemented with any or a combination of the following technologies, which are all well known in the art: a discrete logic circuit(s) having logic gates for implementing logic functions upon data signals, an application specific integrated circuit (ASIC) having appropriate combinational logic gates, a programmable gate array(s) (PGA), a field programmable gate array (FPGA), *etc.*

The flow chart of FIG. 3 shows the architecture, functionality, and operation of a possible implementation of the ATM switching system 201 (FIG. 2) software. In this regard, each block represents a module, segment, or portion of code, which comprises one or more executable instructions for implementing the specified logical function(s). It should also be noted that in some alternative implementations, the functions noted in the blocks might occur out of the order noted in FIG. 3. For example, two blocks shown in succession in FIG.3 may in fact be executed substantially concurrently or the blocks may sometimes be executed in the reverse order, depending upon the functionality involved, as will be further clarified herein below.

A program to implement the polling system 200 (FIG. 2), which comprises an ordered listing of executable instructions for implementing logical functions, can be embodied in any computer-readable medium for use by or in connection with an instruction execution system, apparatus, or device, such as a computer-based system, processor-containing system, or other system that can fetch the instructions from the instruction execution system, apparatus, or device and execute the instructions. In the context of this document, a "computer-readable medium" can be any means that can contain, store, communicate, propagate, or transport the program for use by or in connection with the instruction execution system, apparatus, or device. The computer readable medium can be, for example but not limited to, an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor system, apparatus, device, or propagation medium. More specific examples (a nonexhaustive list) of the computer-readable medium would include the following: an electrical connection (electronic) having one or

more wires, a portable computer diskette (magnetic), a random access memory (RAM) (electronic), a read-only memory (ROM) (electronic), an erasable programmable read-only memory (EPROM or Flash memory) (electronic), an optical fiber (optical), and a portable compact disc read-only memory (CDROM) (optical). Note that the computer-readable medium could even be paper or another suitable medium upon which the program is printed, as the program can be electronically captured, via for instance optical scanning of the paper or other medium, then compiled, interpreted or otherwise processed in a suitable manner if necessary, and then stored in a computer memory.

The foregoing description has been presented for purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise forms disclosed. Obvious modifications or variations are possible in light of the above teachings. The embodiment or embodiments discussed were chosen and described to provide the best illustration of the principles of the invention and its practical application to thereby enable one of ordinary skill in the art to utilize the invention in various embodiments and with various modifications as are suited to the particular use contemplated. All such modifications and variations are within the scope of the invention as determined by the appended claims when interpreted in accordance with the breadth to which they are fairly and legally entitled. In concluding the detailed description, it should be noted that it will be obvious to those skilled in the art that many variations and modifications can be made to the preferred embodiment without substantially departing from the principles of the present invention. All such variations are intended to be

included herein within the scope of the present invention, as set forth in the following claims.

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